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Early signs of mathematics anxiety?

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Abstract

Mathematics anxiety refers to individual's negative affect when engaging in numerical and mathematical tasks. Researchers have recently connected high math anxiety to lower performance on math tasks, developmental dyscalculia, and lower self-efficacy towards math learning. Math anxiety scales have been made and validated mainly for secondary school and high school students. In our paper we are looking for early signs of math anxiety using a Pictorial Test (37 pictures) which we have developed for 6 to 8 year old children. Children were asked to concentrate on one picture at a time and to write down spontaneously their emotional and mathematical ideas. Most powerful sources of sadness were real life subjects as animals and human beings. We also found high negative correlation between sadness (☹) and math productions (r=-.60**). As a conclusive remark we are looking for ways in which school can respond to the learning challenges of these children.

Keywords: Mathematics anxiety, children, mathematics, emotions, Pictorial Test;

1. Introduction

Math anxiety is defined as negative affective responses to mathematics. These are generally feelings of tension or fear that interfere with mathematics performance (Ashcraft, 2002, 181). Reasons for math anxiety are usually classified as environmental, personal or cognitive. Environmental causes can include negative experiences in math classes or with particular math teachers. Personal causes include low self-esteem, lack of confidence and the influence of previous negative experiences. Cognitive causes involve innate characteristics, being either low intelligence or simply poor cognitive abilities in mathematics. (Rubinsten & Tannock, 2010, 47.) Researchers have recently connected high math anxiety to lower performance on math tasks, developmental dyscalculia, and lower self-efficacy and beliefs towards math learning. (e.g. Maloney, Ansari & Fugelsang, 2011; Rubinsten & Tannock, 2010; Hoffman, 2010; Kesici & Erdoğan, 2010). If we do not take note of children's math anxiety they may develop an overall avoidance of mathematics which might have life-long effects. Measures of mathematics anxiety have been developed and validated mainly for secondary school students. (e.g. from Richardson & Suinn, 1972, to Bai, 2011). According to Ashcraft (2002, 184) there has been no thorough empirical work on the origins or causes of math anxiety. The cumulative process of unpleasant experiences in mathematics is so vigorous that we decided to study early signs of math anxiety.

Uncomfortable experiences evoke sad emotions which might, before long, lead to anxiety. According to Janke (2003) 6 to 8 year old children are able to categorize correctly symptoms of their bodily change accompanying

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emotions like sadness and anxiety. Davis III, Nida, Zlomke, and Nebel-Schwalm (2009, 228-229) have found in their research that student reporting learning disabilities suffered from an impaired sense of well-being associated with anxious and sad feelings.

Children's development during preschool and primary school is crucial because children are developing their feelings of competence and beliefs in their skills. Without encouragement they will doubt their ability to be successful. Because of this crucial stage of development it is worth to study children's emotions towards mathematics.

2. Method

2.1. The Pictorial Test

The basic idea of our Pictorial Test is similar to Harter's and Pike's (1984) Pictorial Scale of Perceived Competence and Social Acceptance for Young Children. We have also found some similarities with a Dutch research project concerning the use of children's literature, especially picture books, as a meaningful context for learning mathematics (van den Heuvel-Panhuizen, van den Boogaard & Doig, 2009; van den Heuvel-Panhuizen & van den Boogaard, 2008). Following two viewpoints were the main basis for picture and subject matter selection. First, we had to take account of 6 to 8 year old children's developmental level. Secondly, we share two philosophical viewpoints about mathematics: mathematics lies everywhere, and mathematics is a formal language. For the revised Pictorial Test we selected 37 pictures of the mathematical world in a wide sense.

The Picture Test consists of twelve drawings, sixteen photos, and nine traditional mathematical tasks. 37 pictures have been grouped in six subject matters of pictures (in parentheses there are the numbers of pictures within the subject matter):

1. human beings (7)
2. culture products (7)
3. toys and fairy-tale creatures (6)
4. nature and nature products (3)
5. constructed environment (3)
6. mathematical issues (11) (4 comparisons, 2 one to one correspondence, 5 problems)

The rationale for using these contents reflects four basic ideas. 1) We see mathematics as human and cultural science. 2) Because the test is developed for children there are pictures about toys and fairy-tale creatures. 3) Children's developing environments consist of either nature or constructed environments or both of them. 4) Within school mathematics 6 to 8 year old children are developing and learning to compare, to find one to one correspondences, and to solve problems. In the next Fig. 1 we represent examples of two mathematical worlds (real life and school mathematics).

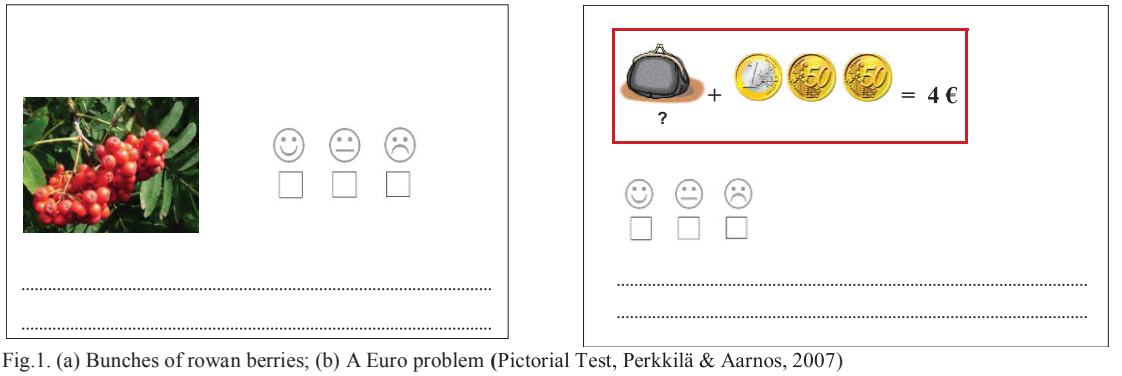

Fig.1. (a) Bunches of rowan berries; (b) A Euro problem (Pictorial Test, Perkkilä & Aarnos, 2007)

When children are looking at the pictures of our Pictorial Test, they have plenty of opportunities to spontaneously express their feelings, mathematical ideas, and meaning makings. In order to make emotional expression easy for children we used a familiar three point's smiley-face Likert-scale (happy, neutral, and sad). Children were asked to evaluate all pictures from three viewpoints: 1) Is there any kind of mathematics in the picture? 2) How do you feel while finding mathematics in the picture? 3) Please, write down your own mathematical ideas about the pictures. With this open instruction, we want to give children opportunities to freely express themselves. There are no right and wrong answers. Thus our Pictorial Test is meant to be free from test anxiety.

2.2. Procedure

We administered a preliminary test to determine the scientific quality of our test. The main interest of our pre-test was the applicability of our test to 6 to 8 year old children. Furthermore, we wanted to identify any areas needing elaboration or clarification. On the basis of the pretest we developed the instructions for children and guidance for teachers. Data gathering was organised during the spring term in co-operation with primary school teachers. The Pictorial Test was presented in 23 school classes to 300 children from preschool class to grade 2.

The Pictorial Test was encoded as follows:

1. Smiley-face Likert-scale: 1 = sad, 2 = neutral, 3 = joyful.
2. Children's mathematical expressions (under the pictures): 0 = nothing, 1 = numbers, 2 = exercises (e.g., 2 + 3), 3 = solved exercises (e.g., 2 + 3 = 5), 4 = amount expressions and comparisons, 5 = word problems, 6 = mental models.

Table 1 contains statistical descriptions of the main scales. Originally we sub-divided the pictures into two groups, school mathematics and real life mathematics. We created two mathematical scales by adding the frequencies of children's mathematical expressions towards either school or real life mathematics. For example in Fig. 1 (a) rowan berries are grouped in real life math and (b) the Euro problem in school mathematics. We also created our scale for Sadness by adding children's sad scores given for the Likert-scale of all 37 pictures.

Table 1. Statistical descriptions of main scales

Scales	Minimum	Maximum	Mean	Std.Deviation
School Mathematics	9,00	90,00	52,63	12,83
Real Life Mathematics	21,00	90,00	55,82	14,40
Sadness	0,00	32,00	7,00	5,84

The results were analysed as follows. The sources of sadness: Which pictures children enjoyed least were analysed by distributions and correlations. The connections between mathematical expressions and sadness: Correlations were counted between math scales and sadness scale. The connection between these two scales is also highlighted by t-test and variance analysis. Finally, we will give voice to some sad children.

3. Results

3.1. The sources of sadness

Children expressed the saddest emotions towards the fairy-tale pictures of a spider, a cat, and a bee without making any mathematical marks. These difficulties and sad emotions might be an early sign of math anxiety. To find mathematics in these pictures, demands creativity and freedom of mind. We also counted Pearson Correlations between subject matters of our Pictorial Test and children's sadness. The correlations varied from -.41 to -.62. All correlations were statistically significant (**) in spite of the differences between correlations. Human beings and culture products seem to be the most important sources of sadness. These sad experiences may evoke math anxiety if children are growing in non-stimulating environments. Non-stimulating environments can narrow a child's view of mathematics which may cause difficulties in math learning.

3.2. The connections between mathematical expressions and sadness

Children's mathematical expressions can be viewed either as a whole scale, as two subscales of school and real life mathematics or as different mathematical skills. The correlation of sadness (☹) and all math productions was -.60**. This connection is dynamic by nature. Either the sadness decreases math productions or the difficulties in math expressions increases anxiety.

We conducted further examinations comparing means of school and real life mathematics between quartile groups of the sadness scale (Table 2). The sadness is equally connected to both math worlds – school and real life mathematics. This is a sign of the holistic emotional state of math anxiety.

Table 2. The means of school and real life mathematical productions between lower and upper sad groups

Scales	Lower sad group	Upper sad group	t	p
School Mathematics	59,1	47,2	8,1	<.001
Real Life Mathematics	63,1	48,0	9,7	<.001

According to Levene's Test for Equality of Variances either sadness significantly decreased children's productions of numbers, exercises, word problem, and mental models or difficulties in different mathematical skills increases math anxiety.

After the quantitative analysis, we will enrich the results with some case examples of the data. These children have the highest scores on the sadness scale. Jere, a pre-schooler boy, expressed sad emotions towards two issues. The first one was the social situations in pictures because he did not like to learn mathematics with other children. The second one was mathematical meanings in the pictures. Jere said that pots, stones, bees, spider, bikes, Mulltilink-bricks etc. do not make sense for him. On the basis of Jere's answers, for some reason, he has grown apart from mathematics during his early years. Sad emotions of another pre-schooler boy, Atte, and a first-grader girl, Jemina, were connected to their conceptions about their poor mathematical performance. These cases support the hypothetical connection between early math anxiety and mathematical competence. A first-grader boy, Joonas, expressed his sad emotions using words "Boring, boring, boring ..."

On the basis of these results children might have a restricted emotional and cognitive relationship towards mathematics. Despite the children's young age, the early signs of math anxiety can be seen clearly, but at the same time they are very holistic. This developmental state should not be neglected because of children's lifelong learning paths. According to Murrah (2010, 54) school entry math skills are the strongest predictor of later math abilities across fifth grade.

4. Conclusion

Compared to former research results we found a) a greater correlation between sadness and math productions (-.60) than e.g. Bai (2011) has found (-.38), and b) more holistic effects of early math anxiety on mathematics performance than e.g. Maloney, Ansari, and Fugelsang (2011), who have argued that math anxiety has a high effect on numerical magnitude.

Krinzinger, Kaufmann and Willmes (2009) have also studied primary school children between first and third grade. They have found a strong influence of calculation ability and math anxiety on the general emotional relationship towards mathematics. Slightly contrasting with our research they found no effect of math anxiety on calculation ability.

We are considering our research results in the frame of Rubinsten's and Tannock's classification of the reasons for math anxiety. Environmental causes for early math anxiety can include negative experiences with parents or teachers who might affect children by their negative attitudes and beliefs towards mathematics (e.g. Bekdemir, 2010). Early personal causes of math anxiety involve negative emotions and a holistic embarrassment towards mathematics. Cognitive causes can include restricted view of mathematics in general.

As a final remark we are reflecting on how school can respond to the math learning challenges of anxious children. Wei (2010) has studied if an animated pedagogical agent could help decrease student's math anxiety. The benefits of animated pedagogical agents include enhanced information presentation; increased sense of ease and comfort, increased motivation, enhanced learning. The pedagogical agent contributed significantly to most anxious students. (Wei, 2010, 17, 59.) The mathematical environments should embed learning experiences in daily routines that engage children in real life activities which could e.g. be based on the Reggio Emilia Approach. Within the context of developing number sense this approach could include 1) project work, 2) documentation, 3) recycled materials, 4) integration of the arts and mathematics education, and 5) integration of play and mathematics education. (Linder, Powers-Costello & Stegelin, 2011, 30-31.) According to Geist (2010, 29), there are curricular alternatives that can decrease mathematics anxiety. From our point of view these curricular alternatives include child-centered aims, open math learning and teaching environments, encouraging positive assessment of mathematics learning. It is also important that teachers reflect their teaching approaches because these might have influences on children's math anxiety (Newstead, 1998, 63-66). These above-mentioned remarks could have a strong positive effect on children's lives for many years thereafter.

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